ITEM 1

San Diego State University Research Foundation

Title:	Energy Innovations Small Grant Program Electricity Research Solicitation 10-01
Amount:	$379,651.00
Term:	12 Months
Contact:	Patrick McCarthy
Committee Meeting:	12/1/2010

Recommendation

Staff respectfully recommends approving the four highest ranking research grant applications from the Energy Innovations Small Grant (EISG) electricity solicitation 10-01 in the amount of $379,651. Staff recommends placing this item on the discussion agenda of the Energy Commission Business Meeting.

Issue

The EISG program is a component of the Public Interest Energy Research (PIER) program that is managed by the California Energy Commission. The purpose of the PIER program is to provide benefit to California electricity and natural gas ratepayers by funding energy research, development and demonstration (RD&D) projects that are not adequately provided for by competitive and regulated energy markets.

The Energy Commission recognizes the need for a program to support the early development of promising new energy technology concepts, a niche not covered by PIER general solicitations that focus primarily on development of established concepts. The Energy Commission established the EISG program to meet this need. The EISG program provides up to $95,000 for hardware projects and $50,000 for modeling projects to small businesses, non-profits, individuals and academic institutions to conduct research that establishes the feasibility of new, innovative energy concepts. Research projects must target one of the PIER program areas, address a California energy problem and provide a potential benefit to California electric and natural gas ratepayers.

Background

The Energy Commission has conducted the EISG program since its initiation in 1998 by issuing multiple competitive solicitations per year for new and innovative concepts that, if proven feasible, are expected to open new paths to public interest energy research and development and subsequent public benefit. Three annual surveys of completed projects show that 50 percent of the completed projects attract follow-on RD&D funding from a wide variety of sources, thus enabling the innovative development to continue beyond EISG grant funding. The gross follow-on funding is some 30 times the total Energy Commission grant funding to all completed EISG projects since the beginning of the program. Approximately 85 percent of the follow-on development work is located in California.

Proposed Work

The Energy Innovations Small Grant Program solicitation 10-01 yielded the following response:

- 61 grant applications were received for consideration

- 22 passed initial screening and advanced to technical review
- 14 exceeded the minimum required score in technical review and advance to the PTRB
- 4 proposals were recommended for funding by the PTRB valued at $379,651.

The four proposals that are being recommended for funding are as follows:

Project Title: Flameless Combustion in Air-Cooled, Hybrid Solar Central Receivers
Principle Investigator: Fletcher J. Miller, San Diego State University (San Diego, CA)
Rank: 1
Amount: $94,940 - 2nd Submittal
Project Summary:
The goal of this project is to determine the feasibility of a gas cooled central receiver for heliostat utility scale solar thermal electricity generation. The system will be a hybrid configuration designed to use natural gas at very low concentrations suitable for flameless combustion, when necessary, to achieve consistent power production during times of reduced solar input. This project will enable the use of a Brayton gas turbine as opposed to the conventional steam powered Rankine cycle system, which will further increase overall efficiency.

Project Title: Development of Flexible Die Sensitized Solar Cells
Principle Investigator: Dr. Lei Kerr, Miami University, (Oxford, OH)
Rank: 2
Amount: $94,931 - 1st Submittal
Project Summary:
This proposal seeks to determine the feasibility of creating flexible Dye Sensitized Solar Cells (DSSC) by overcoming the specific challenges related to this generation technology. The research will focus on the development of an inorganic semiconductor to replace the liquid electrolyte used in current glass encased cells, and on the employment of modern paper making and coating technologies to replace the glass. These advances will enable DSSC to compete with established thin film cells.

Project Title: Fabrication of Doped Nanowires for High-Temperature Thermoelectric Materials
Principle Investigator: Ruxandra Vidu, NanoRIS, (Citrus Heights, CA)
Rank: 3
Amount: $94,780 - 1st Submittal
Project Summary:
This project seeks to assess the feasibility of fabricating doped nanowires, from cobalt and antimony, for high temperature thermoelectric (TE) materials to increase conversion efficiency in TE devices and reduce thermal waste. This design builds on the patented "nanocable" technology developed at UC Davis by the Primary Investigator.

Project Title: High-Efficiency LED-based Linear Flourescent Replacement Lamp

Principle Investigator: N. Narendran, Lighting Research Center, Rensselar Polytechnic Institute, (Troy, NY)
Rank: 4
Amount: $95,000 - 1st Submittal
Project Summary:
This project will determine the feasibility of developing an energy-efficient Light Emitting Diode (LED) based lamp that will effectively replace four-foot fluorescent lamp technologies. This linear LED replacement lamp, which will use the Lighting Research Center's patented scattered photon extraction technology, could far exceed the efficacy, light output, and performance of currently available linear LED replacement lamps.

Project Summary
Flameless Combustion in Air-Cooled, Hybrid Solar Central Receivers
Fletcher Miller

Solar central receivers transform the sun's radiation into thermal energy that can be used to generate electricity (1). A field of mirrors (heliostats) focuses solar radiation onto the receiver situated on top of a large tower. The central receiver heats a working fluid, and the thermal energy from this fluid is used to drive a turbine. To date, only liquid-cooled receivers have been developed for commercial applications. Liquid-cooled receivers coupled to a Rankine cycle are limited by material constraints in the temperatures and solar concentration ratios they can utilize. In contrast, the gas-cooled receiver under development at SDSU can utilize high concentration ratios, and efficiently transform solar radiation into thermal energy. Gas-cooled receivers have the potential to supply high efficiency, gas turbine (Brayton) power cycles through the production of high temperature process air. Of major significance, water usage (which is a critical concern in many arid regions suitable for solar energy) is greatly reduced by the introduction of a gas turbine. The lack of adequate water resources has been cited as a major environmental constraint to the solar development of in the California desert.

Fossil fuel combustion is often used in concentrating solar power (CSP) plants as a supplemental energy source. The current project is examining flameless combustion, also called high temperature air combustion (2) or flameless oxidation (3), which is a novel type of combustion wherein a fossil fuel releases heat without the production of visible flames. This process often takes place at high temperatures (>800 C for methane) and low volumetric fuel concentrations (below the normal lean flammability limit). Flameless combustion is currently studied for industrial burner and combustor technology because it significantly reduces the amount of pollution formed, as compared to standard combustion techniques (4).

The goal of this project is to determine the feasibility of employing flameless combustion within an air-cooled solar central receiver. The receiver will be designed to accommodate combustion, so that in periods of low solar thermal input such as during cloud transients, natural gas may be used as a supplemental heat source to ensure steady state operation. Hybridization is essential for maintaining power plant reliability, as no high temperature thermal storage option is currently available for gas turbine systems. In past experiments by others with gas-cooled receivers, hybridization via a downstream natural gas combustor was unsuccessful due to the high temperature solar receiver output (5). Flameless oxidation in the receiver is a potential mechanism to increase the temperature of the working fluid without having a separate combustor. There is no previous research in the area of combining flameless combustion and a gas-cooled solar receiver, making this concept unique.

The receiver constructed in the project will be a laboratory-scale small particle heat exchange receiver (6). This type of receiver uses small, absorbing carbon particles to transform solar radiation into thermal energy directly within a gas stream. This project is complementary to on-going research at San Diego State University's Combustion and Solar Energy Laboratory where large-scale, small particle heat exchange receivers (SPHER's) are studied for commercial applications (7). A lab-scale SPHER will be built from highly heat resistant materials. The hybridized receiver will be tested at a range of air flow rates, particle loadings, and natural gas concentrations. A solar simulator will be constructed to provide concentrated radiation to the receiver at wavelengths near that of actual solar radiation. The efficiency of the receiver will be calculated, and the effectiveness of hybrid operation will be determined by measuring temperatures and outlet natural gas concentrations. The temperature and flammability limits of flameless combustion in the presence of small carbon particles, a subject of greater scientific concern to combustors in general, will be determined.

Project Summary

Development of Flexible Dye Sensitized Solar Cells

Principle Investigator: Dr. Lei L. Kerr
Department of Paper and Chemical Engineering, Miami University of Ohio, Oxford, OH 45056

Dye sensitized nanocrystalline solar cell (DSSC) is one of the most promising third generation photovoltaic technologies. 11% efficiency has been achieved on glass substrate. The problem with the glass substrate is its rigidity and heavy weight. Lightweight DSSCs on a flexible polymer, metal or paper substrates are important for the applications of portable power source and low cost PV production. However, current flexible DSSC manufacturing techniques result in much lower cell efficiency and poor cell stability compared to that on glass substrates. The major cause for flexible DSSCs poor performance is the light absorption and instability of the I^{3-}/I^- liquid electrolytes. This proposal seeks to solve this technological challenge. Wide bandgap p-type inorganic semiconductor will be used to replace the liquid electrolyte to improve the light harvesting and stability of flexible DSSCs. A novel approach of deep level transient spectroscopy (DLTS) will be used to investigate the defects and the trapping mechanism in these p-type semiconductors which are directly related to the flexible DSSC solar cell performance. In addition to the commonly used polymer and metal substrates, paper substrates will be explored for the first time in this proposal for solar cell applications. Modern paper making and coating technologies which have precise process control will be employed which has great potential to lower solar cell manufacturing cost. Both paper and photovoltaic industries will benefit from this innovation. This research exposes graduate and undergraduate students to modern engineering and science in the areas of photovoltaics and nanotechnology; therefore directly impacting their education. With the increased workforce demand in the field of photovoltaic industries, this project will provide the basic training for the photovoltaic workforce of tomorrow.

Project Summary

Fabrication of Doped $CoSb_3$ Nanowires for High-Temperature Thermoelectric Materials

Principal Investigator: Dr. Ruxandra Vidu

This project seeks to assess the feasibility of fabricating doped $CoSb_3$ nanowires for high temperature thermoelectric (TE) materials to increase conversion efficiency in TE devices and reduce thermal waste. Doped $CoSb_3$ skutterudite will be grown by electrochemical (EC) methods using template synthesis. For the purpose of this work, the template will be part of the composite nanowires material, but it will not be optimized for TE properties. The composition of doped $CoSb_3$ nanowires will be engineered so that the thermoelectric properties will be greatly enhanced. We expect this particular doping treatment alone to reduce thermal conductivity of nanostructured $CoSb_3$ skutterudite to a greater degree compared to electrical conductivity due to differences in their respective scattering lengths. This research will also lead to tailored thermoelectric properties of the nanowire arrays.

Thermoelectrics have long been too inefficient to be cost effective in most applications. This novel nanostructured thermoelectric material will use a template synthesis that will be easy to incorporate into today's thin film technology. This technology enables us to integrate multiple homo and hetero-junctions into a singular nanoengineered thermoelectric device. This technology is the only one that allows us to integrate and engineer multiple junctions using a finely tuned electrochemical process. Eventually, this technology has the potential to yield the ultimate goal for thermoelectric systems, efficient solid-state devices for cooling and harvesting waste thermal energy. Addressing these challenges requires an interdisciplinary approach, which is fueled by recent advances on thermoelectric nanostructures.

More efficient materials are needed to expand the commercial applications of thermoelectric devices. $CoSb_3$ is the most promising thermoelectric material to replace PbTe-based alloys. The binary skutterudite compound cobalt triantimonide $CoSb_3$ is particularly interesting because it displays interesting electrical properties. The overall performance of this material remains however low [1-2] due to an excessive value of its lattice thermal conductivity. Thermoelectric properties of $CoSb_3$ are largely affected by doping [3-5]. For example, the substitution of Co by Ni was found to be particularly efficient [6].

Our approach to manufacturing high-efficiency thermoelectric materials is to combine the chemistry (rattling effect) and the size effects (quantum confinement). Our group has already obtained $CoSb_3$ nanowires and demonstrated compositional and crystalline requirements for this compound. In this project, we take another challenge to demonstrate that that p- and n-doped $CoSb_3$ can be fabricated in on step process by electrochemical deposition from aqueous solutions. NanoRIS's complex research and UC Davis expertise will advance the state of the technology closer to being cost competitive. The technology is very versatile and the nanostructures can be made on virtually any substrate and template. The proposed research will also result in a significant improvement in the power to weight ratio of the thermoelectric device.

Project Summary

Title High-Efficiency LED-based Linear Fluorescent Replacement Lamp
Principal Investigator Nadarajah Narendran, Ph.D., FIES

In this project, the Lighting Research Center (LRC) of Rensselaer Polytechnic Institute in Troy, New York will determine the feasibility of developing an energy-efficient, linear light emitting diode (LED) based lamp that will effectively replace four-foot linear fluorescent lamp technologies. This linear LED replacement lamp, which will use the LRC's patented scattered photon extraction (SPE) technology, will far exceed the efficacy, light output, and performance of currently available linear LED replacement lamps. The lamps developed in this project will meet the following performance objectives:

- Easily retrofit into current luminaires that use linear fluorescent lamps
- Exhibit similar lighting characteristics (luminous flux, distributions and uniformity, and color appearance and rendering properties) as currently available linear fluorescent lamps
- Provide a lamp luminous efficacy of 150 lm/w, which will result in a luminaire luminous efficacy of greater than 110 lumens per watt (lm/W)
- Exhibit a useful lamp-life of over 50,000 hours with less than 10% lumen depreciation
- Be able to be manufactured, assembled, and distributed cost-effectively
- Provide a reasonable payback to the consumer through energy and maintenance savings.

Four-foot linear fluorescent lamps are the most widely used lighting technology in commercial and industrial applications in the United States (US). These lamps are generally efficient, inexpensive, and provide useful lives of 20,000 hours, on average. A major drawback of fluorescent technology, however, is the use of mercury in each lamp. With building practices moving away from the use of hazardous materials in buildings, it is only a matter of time before building owners, occupants, and consumers begin objecting to the use of fluorescent lamps in the buildings which they own and occupy. However, linear fluorescent lamps continue to enjoy a significant portion of market share, because no cost-effective and efficient alternative has been developed that exhibits superior qualities.

The LED-based linear fluorescent lamp replacement that will be explored in this project will exhibit vastly superior qualities to current linear LED lamps and will be much more attractive to designers and builders because it will provide a longer useful life, significantly higher light output, superior color qualities, lower production costs, and significantly higher luminous efficacy. The widespread use of these lamps in California will reduce electric energy consumption in the State by up to 3 billion kilowatt hours per year.

In order to meet the aggressive milestones defined above within this one-year project, the LRC research team will address a number of important issues in the following areas:

A. Identifying the most efficient blue LED light sources available
B. Exploiting advanced SPE optical technology to provide enhanced efficacy, light output, distribution and superior color qualities
C. Lamp design and system packaging including heat dissipation, electronics integration, and size reduction